IS 12062 (1987): Method for measurement of exhaust smoke emitted by agricultural tractors [FAD 21: Farm Implements and Machinery]

BLANK PAGE


*Indian Standard*

# METHOD FOR MEASUREMENT OF EXHAUST SMOKE EMITTED BY AGRICULTURAL TRACTORS

UDC 631·372 : 629·114·2 : 621·43·019·9



**BUREAU OF INDIAN STANDARDS**
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

**Gr 3** *October* 1987

# *Indian Standard*

# METHOD FOR MEASUREMENT OF EXHAUST SMOKE EMITTED BY AGRICULTURAL TRACTORS

Agricultural Tractors and Power Tillers Sectional Committee, AFDC 52

| *Chairman* | *Representing* |
|---|---|
| PROF M. M. MEHTA | Escorts Limited, Faridabad; *and* Indian Society of Agricultural Engineers, New Delhi |
| *Members* | |
| SHRI RIPDAMAN SINGH ( *Alternate* to Prof M. M. Mehta ) | Escorts Limited, Faridabad |
| SHRI J. P. SAXENA ( *Alternate* to Prof M. M. Mehta ) | Indian Society of Agricultural Engineers, New Delhi |
| DR A. ALAM | Indian Council of Agricultural Research, New Delhi |
| SHRI A. V. ALEXANDER<br>SHRI A. JINDAL ( *Alternate* ) | Escorts Tractors Limited, Faridabad |
| SHRI BHUPENDRA | National Agricultural Co-operative Marketing Federation of India Limited, New Delhi |
| SHRI A. K. CHAKRAVARTY | National Bank for Agriculture and Rural Development, Bombay |
| SHRI CHANDRA MOHAN<br>SHRI G. S. RIHAL ( *Alternate* I )<br>SHRI S. S. GREWAL ( *Alternate* II ) | Punjab Tractors Limited, Ropar |
| SHRI N. C. GUPTA | Auto Tractors Ltd, Pratapgarh |
| SHRI K. S. LAMBA | Development Commissioner ( Small Scale Industries ) ( Ministry of Industry ), New Delhi |
| SHRI G. N. MEHTA<br>SHRI G. C. PATEL ( *Alternate* ) | Gujarat Tractors Corporation Ltd, Vadodara |
| SHRI S. K. MISHRA<br>SHRI R. S. DASS ( *Alternate* ) | Central Farm Machinery Training and Testing Institute ( Ministry of Agriculture ), Budni |
| DR V. K. MITTAL<br>DR R. B. RAM ( *Alternate* ) | Punjab Agricultural University, Ludhiana |
| SHRI J. S. MUDHAR<br>SHRI G. B. LAL ( *Alternate* ) | HMT Limited ( Tractor Division ), Pinjore |

( *Continued on page* 2 )

( *Continued from page* 1 )

| *Members* | *Representing* |
|---|---|
| SHRI H. M. MUTTA | Mahindra & Mahindra Ltd, Bombay |
| SHRI A. R. SONALKAR ( *Alternate* ) | |
| SHRI A. T. NAHENDER | VST Tillers Tractors Limited, Bangalore |
| SHRI V. PRASHANT RAO ( *Alternate* I ) | |
| SHRI K. CHANDRASEKHAR RAO ( *Alternate* II ) | |
| SHRI R. NIGAM | Central Mechanical Engineering Research Institute ( CSIR ), Durgapur |
| SHRI K. N. GAUR ( *Alternate* ) | |
| DR T. P. OJHA | Central Institute of Agricultural Engineering ( ICAR ), Bhopal |
| SHRI J. PRASAD ( *Alternate* ) | |
| SHRI S. B. PANDYA | National Farmers Organisation, New Delhi |
| SHRI R. N. PATIL | Ministry of Agriculture ( Department of Agriculture and Co-operation ), New Delhi |
| SHRI V. A. PATIL | Northern Region Farm Machinery Training and Testing Institute ( Ministry of Agriculture ), Hissar |
| SHRI R. TIWARI ( *Alternate* ) | |
| SHRI V. V. PATIL | Bharat Krishak Samaj, New Delhi |
| SHRI HUDSON PETER | Kerala Agro Machinery Corporation Limited, Ernakulam |
| SHRI JOHN MATHAI ( *Alternate* ) | |
| SHRI S. R. PRABHAKAR | Bharat Earthmovers Ltd, Bangalore |
| SHRI C. GANGADHARAIAH ( *Alternate* ) | |
| SHRI M. RAMASWAMY | Tractors and Farm Equipment Ltd, Madras |
| SHRI S. RANGANATHAN ( *Alternate* I ) | |
| SHRI G. VENKATARAMANAN ( *Alternate* II ) | |
| DR S. SATYAMURTY | Eicher Goodearth Limited, Ballabgarh |
| SHRI SUNIL KUMAR ( *Alternate* ) | |
| SHRI UDAYAN SEN | Directorate General of Technical Development ( Ministry of Industry ), New Delhi |
| SHRI T. PURNANANDAM, Director ( Agri & Food ) | Director General, BIS ( *Ex-officio Member* ) |

*Secretary*

SHRI R. N. SHARMA
Joint Director ( Agri & Food ), BIS

# AMENDMENT NO. 1 AUGUST 2006
# TO
# IS 12062 : 1987 METHOD FOR MEASUREMENT OF EXHAUST SMOKE EMITTED BY AGRICULTURAL TRACTORS

( *Page* 7, *Appendix* A, *clause* **A-2.5.1** ) — Substitute the following for the existing text:

'The light-absorption coefficient $k$ shall be calculated using the formula:

$$\varnothing = \varnothing_{o}e^{-kL}$$

where

$L$ = effective length of the light path through the gas to be measured,
$\varnothing_{o}e$ = incident flux, and
$\varnothing$ = emergent flux.

If the effective length $L$ of a type of opacimeter cannot be accessed directly from its geometry, the effective length shall be determined in one of the following ways:

a) by the method specified in the **A-3**,
b) by correlation with another type of opacimeter for which the effective length is known.'

( FAD 11 )

Reprography Unit, BIS, New Delhi, India

# *Indian Standard*

# METHOD FOR MEASUREMENT OF EXHAUST SMOKE EMITTED BY AGRICULTURAL TRACTORS

## 0. FOREWORD

**0.1** This Indian Standard was adopted by the Bureau of Indian Standards on 30 June 1987, after the draft finalized by the Agricultural Tractors and Power Tillers Sectional Committee had been approved by the Agricultural and Food Products Division Council.

**0.2** With the increasing awareness for keeping the environment free from pollution, efforts are being made to minimize the smoke level emitted by vehicles, be it for transport or for agricultural operations. It was felt necessary, at first instance, to rationalize the test methodology for this characteristics as applicable to agricultural tractors. Test method for engines and diesel vehicles excepting agricultural tractor has been covered in IS : 10000 ( Part 10 )-1980* and IS : 8118-1987† respectively.

**0.3** In preparation of this standard, assistance has been taken from ISO 789/4-1982 Agricultural tractors — Test procedures — Part IV Measurement of exhaust smoke, issued by the International Organization for Standardization.

**0.4** In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960‡.

## 1. SCOPE

**1.1** This standard covers method for measuring smoke emitted by the engine of agricultural tractors operating at a steady speed.

*Methods of tests for internal combustion engines : Part 1 Tests for smoke levels, limits and corrections for smoke levels for variable speed compression ignition engines.

†Smoke emission levels for diesel vehicles (*first revision* ).

‡Rules for rounding off numerical values ( *revised* ).

## 2. APPARATUS

**2.1** The following apparatus are required:

a) Dynamometer, and

b) Opacimeter complying with the requirements of Appendix A, and installed and used in accordance with Appendix B [ *see also* **B-2** and Appendix C of IS : 10000 ( Part 10 )-1980* ].

## 3. TEST CONDITIONS

**3.1 Test Laboratory** — The temperature and atmospheric pressure in the test laboratory shall be such that the factor, $F$, when determined from the following formula, is greater than 0·98 and less than 1·02:

$$F = \frac{750}{P} \times \frac{T}{298}^{0{\cdot}65} \quad {}^{0{\cdot}5}$$

where

$P$ = Atmospheric preessure, mmHg; and

$T$ = Thermodynamic temperature in test laboratory, $K$

NOTE – 1 mmHg = 133·322 Pa.

### 3.2 Tractor Condition

**3.2.1** The tractor submitted/selected shall be in good mechanical condition. The engine shall be run-in according to the manufacturer's instructions.

**3.2.2** The engine settings and working conditions, particularly coolant and oil temperature, shall be those prescribed by the manufacturer.

**3.2.3** The tractor shall be fitted with those equipment/auxiliaries with which power take-off power test (*see* IS : 12036-1987†) is to be conducted.

**3.2.4** The exhaust device shall not have any orifice through which the gases emitted by the engine could be diluted.

**3.3 Fuel** — If possible, fuel conforming to IS : 1460-1974‡ should be used. If it is not possible, the analysis of the fuel shall be made and incorporated.

---

*Methods of tests for internal combustion engines : Part 10 Tests for smoke levels, limits and corrections for smoke levels for variable speed compression ignition engines.

†Method of test for power take-off and belt-pulley performance of Agricultural tractors.

‡Specification for diesel fuels ( *second revision* ).

## 4. PROCEDURE

**4.1** The opacity of the exhaust smoke produced by the tractor shall be measured with the engine running under 80 percent of the maximum load ( maximum load shall be interpreted as the maximum torque at each of the six relevant engine speeds ) and at steady speed. Six measurements shall be made at engine speeds spaced out uniformly between the:

a) speed corresponding to maximum power, and

b) higher of the following two speeds:

1) 55 percent of engine speed at maximum power, and

2) 1 000 rev/min.

**4.1.1** The extreme points of measurement shall be situated at the limits of the intervals defined above.

**4.2** In case a tractor engine is fitted with an air pressure charger which is accompanied by an increase in the quantity of fuel injected, the measurements shall be made both with and without air pressure charger working, if so designed.

**4.2.1** For each engine speed, the result of the measurement shall be the higher of the two figures obtained.

**4.3** For each of the six engine speeds at which the opacity is measured, the nominal gas flow rate, $q$, expressed in litres/second, shall be calculated by the following formula:

$$q = \frac{V \times n}{60} \text{ (for two-stroke engines)}$$

$$q = \frac{V \times n}{120} \text{ ( for four-stroke engines )}$$

where

$V$ = cylinder capacity of the engine, in litres; and

$n$ = engine speed, rev/min.

## 5. REPORTING OF RESULTS

**5.1** The results shall be reported in the *pro forma* given in Appendix C. If required, for converting one smoke unit to other, the assistance may be taken from Fig. 3 of IS : 10000 ( Part 10 )-1980*.

*Methods of tests for internal combustion engines: Part 10 Tests for smoke levels, limits and corrections for smoke levels for variable speed compression ignition engine.

# APPENDIX A

[ *Clause* 2.1(b) ]

## CHARACTERISTICS OF OPACIMETERS

### A-1. BASIC SPECIFICATION

**A-1.1** The gas to be measured shall be confined in an enclosure having a non-reflecting internal surface.

**A-1.2** In determining the effective length of light path through the gas, account shall be taken of the possible influence of devices protecting the light source and photoelectric cell. This effective length shall be indicated on the instrument.

**A-1.3** The indicating dial of the opacimeter shall have two measuring scales, one in absolute units of light absorption from 0 to $\infty$ ($m^{-1}$) and the other linear from 0 to 100; both scales shall range from 0 at total light flux to full scale at complete obscuration.

### A-2. CONSTRUCTION

**A-2.1 General** — The design shall be such that, under steady-speed operating conditions, the smoke chamber is filled with smoke of uniform opacity.

**A-2.2 Smoke Chamber and Opacimeter Casing**

**A-2.2.1** The influence on the photoelectric cell of stray light due to internal reflections of diffusion effects shall be reduced to a minimum ( for example, by finishing internal surfaces in matt black and by a suitable general layout ).

**A-2.2.2** The optical characteristics shall be such that the combined effect of diffusion and reflection does not exceed one unit on the linear scale when the smoke chamber is filled with smoke having an absorption coefficient near 1·7 $m^{-1}$.

**A-2.3 Light Source** — The light source shall be an incandescent lamp with a colour temperature in the range from 2 800 to 3 250 K.

**A-2.4 Receiver**

**A-2.4.1** The receiver shall consist of a photoelectric cell with a spectral response curve similar to the photopic curve of the human eye ( maximum response in the range 550 to 570 nm, less than 4 percent of the maximum response being below 430 nm and above 680 nm ).

**A-2.4.2** The construction of the electrical circuit, including the indicating dial, shall be such that the current output from the photoelectric cell is a linear function of the intensity of the light received over the operating temperature range of the photoelectric cell.

### A-2.5 Measuring Scales

**A-2.5.1** The light absorption coefficient, $K$ shall be calculated using the formula:

$$\phi = \phi_0 - KL$$

where

$L$ = effective length of the light path through the gas to be measured,

$\phi_0$ = incident flux, and

$\phi$ = emergent flux.

If the effective length $L$ of a type of opacimeter cannot be assessed directly from its geometry, the effective length $L$ shall be determined in one of the following ways:

a) By the method specified in **A-3**, and

b) By correlation with another type of opacimeter for which the effective length is known.

**A-2.5.2** The relationship between the linear scale ( 0 to 100 ) and the light absorption coefficient $K$ is given by the formula:

$$K = -\frac{1}{L}\log_e\left[1 - \frac{N}{100}\right]$$

where $N$ is a reading on the linear scale.

**A-2.5.3** The indicating dial of the opacimeter shall enable an absorption coefficient of 1·7 $m^{-1}$ to be read with an accuracy of 0·025 $m^{-1}$.

### A-2.6 Adjusting and Testing the Measuring Apparatus

**A-2.6.1** The electrical circuit of the photoelectric cell and the indicating dial shall be adjustable so that the pointer can be reset at zero when the light flux passes through the smoke chamber filled with clean air or through a chamber having identical characteristics.

**A-2.6.2** With the lamp switched off and the electrical measuring circuit, open or short-circuited, the reading on the absorption coefficient scale shall be infinity ( $\infty$ ), and it shall remain at this value when the measuring circuit is reconnected.

**A-2.6.3** An intermediate check shall be carried out by placing a screen representing a gas of known absorption coefficient $K$, between 1·6 and 1·8 $m^{-1}$ measured as described in **A-2.5.1**, in the smoke chamber. The value of $K$ shall be known to within 0·025 $m^{-1}$. The check consist of veryfying that this value does not differ by more than 0·05 $m^{-1}$ from that read on the opacimeter indicating dial when the screen is introduced between the source of light and the photoelectric cell.

### A-2.7 Pressure of the Gas to be Measured and Scavenging Air

**A-2.7.1** The pressure of the exhaust gas in the smoke chamber shall not differ by more than 735 Pa from the atmospheric pressure.

**A-2.7.2** The variations in the pressure of gas to be measured and the scavenging air shall not cause the absorption coefficient to vary by more than 0·05 $m^{-1}$ in the case of a gas having an absorption coefficient of 1·7 $m^{-1}$.

**A-2.7.3** The opacimeter shall be equipped with appropriate devices for measuring the pressure in the smoke chamber.

**A-2.7.4** The limits of pressure variation of gas and scavenging air in the smoke chamber shall be indicated by the manufacturer of the apparatus.

### A-2.8 Temperature of the Gas to be Measured

**A-2.8.1** At every point in the smoke chamber, the gas temperature at the instant of measurement shall be between 70°C and a maximum temperature, specified by the opacimeter manufacturer, such that the readings over this temperature range do not vary by more than 0·1 $m^{-1}$ if the chamber is filled with a gas having an absorption coefficient of 1·7 $m^{-1}$.

**A-2.8.2** The opacimeter shall be equipped with appropriate devices for measuring the temperature in smoke chamber.

## A-3. DETERMINATION OF EFFECTIVE LENGTH OF THE OPACIMETER

### A-3.1 General

**A-3.1.1** In some types of opacimeter, the gas between the light source and the photoelectric cell, or between transparent parts protecting the source and the photoelectric cell, is not of constant opacity. In such cases, the effective length, $L$ shall be that of a column of gas of uniform opacity, which is necessary in order to obtain the same light absorption as that obtained when the gas is admitted in the normal manner into the opacimeter.

**A-3.1.2** The effective length of the light path is obtained by comparing the reading $N$ of the opacimeter operating normally with the reading $N_0$, obtained with the opacimeter modified so that the test gas fills a well-defined length $L_0$.

**A-3.1.3** It will be necessary to take comparative readings in rapid succession in order to determine the correction to be made for shifts of the 'zero'.

### A-3.2 Procedure

**A-3.2.1** The test gas shall be exhaust gas of constant opacity or a light-absorptive gas of density similar so that of the exhaust gas.

**A-3.2.2** Determine a length, $L_0$ of the opacimeter which can be filled uniformly with the test gas, and the ends of which are substantially at right angles to the light path. This length shall be close to the presumed effective length of the opacimeter.

**A-3.2.3** Measure the mean temperature of the test gas in the smoke chamber.

**A-3.2.4** If necessary, an expansion tank of compact design and sufficient capacity to damp the pulsations may be incorporated in the sampling line as near to the probe as possible. A cooler may also be fitted. The addition of the expansion tank and the cooler shall not unduly disturb the composition of the exhaust gas.

**A-3.2.5** Determine the effective length by passing a sample of test gas alternately through the opacimeter operating normally and through the same apparatus modified as indicated in **A-3.1.2**.

**A-3.2.5.1** Record the opacimeter readings continuously during the test using a recorder having a response time equal to or less than that of the opacimeter.

**A-3.2.5.2** With the opacimeter operating normally, record the reading on the linear scale of opacity $N$ and the mean gas temperature $T$, in Kelvins.

**A-3.2.5.3** With the known length $L_0$ filled with the same test gas, record the reading on the linear scale of opacity, $N_0$ and the mean gas temperature $T_0$, in Kelvins.

**A-3.2.6** The effective length ( $L$ ) may be obtained by the following formula:

$$L = L_0 \frac{T \log_e \left[ 1 - \frac{N}{100} \right]}{T_0 \log_e \left[ 1 - \frac{N_0}{100} \right]}$$

**A-3.2.7** Repeat the test using at least four test gases giving readings evenly spaced between 20 and 80 linear scale.

**A-3.2.8** Take, as the effective length ( $L$ ) of the opacimeter, the arithmetic mean of the effective lengths as calculated in **A-3.2.6**, for each of the gases.

# APPENDIX B

[ *Clause* 2.1 (b) ]

## INSTALLATION AND USE OF THE OPACIMETER

### B-1. SAMPLING OPACIMETER

**B-1.1** The ratio of the cross-sectional area of the probe to that of the exhaust pipe shall not be less than 0·05. The back pressure measured in the exhaust pipe at the intake of the probe shall not exceed 735 Pa.

**B-1.2** The probe shall be a tube with an open end facing upstream in the axis of the exhaust pipe, or of the extension pipe, if one is required. It shall be situated in a section where the distribution of smoke is approximately uniform. To achieve this, the probe shall be placed as far downstream in the exhaust pipe as possible or, if necessary, in an extension pipe so that, if $D$ is the diameter of the exhaust pipe at the outlet, the end of the probe is situated in a straight portion at a distance of at least $6D$ upstream and $3D$ downstream from the sampling point. If an extension pipe is used, no air shall be allowed to enter the joint.

**B-1.3** The pressure in the exhaust pipe and the characteristics of the pressure drop in the sampling line shall be such that the probe collects a sample substantially equivalent to that which would be obtained by isokinetic sampling.

**B-1.4** If necessary, an expension tank of compact design and sufficient capacity to damp the pulsations may be incorporated in the sampling line as near to the probe as possible. A cooler may also be fitted. The addition of the expansion tank and cooler shall not unduly disturb the composition of the exhaust gas.

**B-1.5** A butterfly valve or other means of increasing the sampling pressure may be placed in the exhaust pipe at a distance at least $3D$ downstream from the sampling probe.

**B-1.6** The connecting pipe between the probe, the cooling device, the expansion tank ( if required ) and the opacimeter shall be as short as possible while satisfying the pressure and temperature requirements described in **A-2.7** and **A-2.8**. The pipe shall be inclined upwards from the sampling point to the opacimeter and sharp bends, where soot could accumulate, shall be avoided. If not embodied in the opacimeter, a bypass valve shall be provided upstream.

**B-1.7** A check shall be carried out during the test to ensure that the requirements of **A-2.7** for pressure, and those of **A-2.8** for the temperature in the measuring chamber, are observed.

**B-2. FULL-FLOW OPACIMETER**

**B-2.0** The general precautions to be observed are given below.

**B-2.1** Joints in the connecting pipes between the exhaust pipe and the opacimeter shall not allow air to enter from outside.

**B-2.2** The pipe connecting with the opacimeter shall be as short as possible, as in the case of sampling opacimeters. The pipe system shall be inclined upwards from the exhaust pipe to the opacimeter and sharp bends where soot could accumulate, shall be avoided. A bypass valve may be provided upstream of the opacimeter to isolate it from the exhaust gas flow when no measurement is being made.

**B-2.3** A cooling system may also be required upstream of the opacimeter.

# APPENDIX C

( *Clause* 5.1 )

## SPECIMEN TEST REPORT

**1. Tractor Details**

a) Manufacturer's name and address
b) Tractor type
c) Tractor model
d) Serial number

**2. Engine**

a) Make
b) Model
c) Type
d) Serial number
e) Rated speed, rev/min

**3. Make and Type of Opacimeter**

**4. Emission Levels**

| *Sl No.* | *Date of Test* | *Engine Speed rev/min* | *Nominal Flow Rate q/(1/s)* | *Measured Absorption Values, $m^{-1}$* |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| 5. | | | | |
| 6. | | | | |

**5. Fuel** ( attach specification, if reference fuel is not used ).

*Headquarters*:
Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002
Telephones: 3 31 01 31, 3 31 13 75 Telegrams: Manaksanstha
( Common to all Offices )

| *Regional Offices*: | *Telephone* |
|---|---|
| *Western : Manakalaya, E9 MIDC, Marol, Andheri ( East ), BOMBAY 400093 | 6 32 92 95 |
| †Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola, CALCUTTA 700054 | 36 24 99 |
| Northern : SCO 445-446, Sector 35-C, CHANDIGARH 160036 | 2 18 43<br>3 16 41 |
| Southern : C. I. T. Campus, MADRAS 600113 | 41 24 42<br>41 25 19<br>41 29 16 |
| *Branch Offices :* | |
| 'Pushpak', Nurmohamed Shaikh Marg, Khanpur, AHMADABAD 380001 | 2 63 48<br>2 63 49 |
| 'F' Block, Unity Bldg, Narasimharaja Square, BANGALORE 560002 | 22 48 05 |
| Gangotri Complex, 5th Floor, Bhadbhada Road, T. T. Nagar, BHOPAL 462003 | 6 67 16 |
| Plot No. 82/83, Lewis Road, BHUBANESHWAR 751002 | 5 36 27 |
| 53/5, Ward No. 29, R. G. Barua Road, 5th Byelane GUWAHATI 781003 | — |
| 5-8-56C L. N. Gupta Marg ( Nampally Station Road ), HYDERABAD 500001 | 23 10 83 |
| R14 Yudhister Marg, C Scheme, JAIPUR 302005 | 6 34 71<br>6 98 32 |
| 117/418 B Sarvodaya Nagar, KANPUR 208005 | 21 68 76<br>21 82 92 |
| Patliputra Industrial Estate, PATNA 800013 | 6 23 05 |
| Hantex Bldg ( 2nd Floor ), Railway Station Road, TRIVANDRUM 695001 | 7 66 37 |
| *Inspection Offices* ( With Sale Point ): | |
| Pushpanjali, 205A West High Court Road, Bharampeth Extension, NAGPUR 440010 | 2 51 71 |
| Institution of Engineers ( India ) Building, 1332 Shivaji Nagar, PUNE 411005 | 5 24 35 |

*Sales Office in Bombay is at Novelty Chambers, Grant Road, Bombay 400007 — 89 65 28

†Sales Office in Calcutta is at 5 Chowringhee Approach, P. O. Princep Street, Calcutta 700072 — 27 68 00

Printed at New India Printing Press, Khurja, India.